Automated Robot ARM using Ultrasonic Sensor in Assembly Line

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Abstract – *In today's world, time and man power are important constraints for the completion of tasks. Robots are used in industries to perform simple repetitive tasks. Compared to humans, robots complete tasks faster and with greater accuracy. They are increasingly used in industries to automate tasks in an assembly line for pick and place. Robot arms are used as a pick and place robot in industries. This paper presents a robot arm used as a pick and place robot using a raspberry pi microcontroller. The robot arm can automatically move to a location where the object to be lifted and placed. Ultrasonic distance sensors are installed at the robot arm to recognize the object. The robot arm is used to hold the object and move it to desired destination*

Key Words: Robotics, Automation, Raspberry pi, Ultrasonic distance sensors, Robot hand.

1. INTRODUCTION

In industries, the completion of tasks within the specified time and available man power is an important requirement. Since robots complete the tasks faster when compared to humans, robots are perfect for tasks requiring both speed and accuracy. One such robot is a Robot arm. A robotic arm is an automated mechanical device controlled via special software installed on the dedicated microcontroller. It can be either a standalone device or an element of a human-like robot. The goal of this robot is to imitate human arm motion as precisely as possible. Robotic arms can be used for standard pick and place applications where objects are picked up and moved to other locations in a single plane.

Pick and place robots can execute virtually all material handling operations both cost-efficiently and effectively — whether it's parts assembly, bin picking or packaging applications. Pick and place robots are commonly used in modern manufacturing environments. Pick and place automation speeds up the process of picking up parts or items and placing them in other locations. Automating this process helps to increase production rates. Pick and place robots handle repetitive tasks while freeing up human workers to focus more on complex work.

This paper presents a system that uses a robot arm which will pick the object from source position where the object to be lifted is available with the help of a robotic arm. Ultrasonic sensors are installed at the end-effector of the robot to sense the object. Robot moves towards the destination position by using a robot chassis and placing the object at its desired destination.

2. ULTRASONIC DISTANCE SENSOR

The HC-SR04 is an ultrasonic distance sensor that is used in many applications where measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver. Ultrasonic distance sensor determines the distance to an object by measuring the time taken by the sound to reflect back from that object. It uses ultrasonic sound waves to measure the distance between itself and an object. It can measure distance from 1 inch all the way to 13 feet.

Ultrasonic distance sensor contains 4 pins.

1. Vcc pin
2. TRIG pin
3. ECHO pin
4. GND pin

Fig -1: ULTRA SONIC DISTANCE SENSOR

The Vcc pin is the power supply pin of the sensor. It is connected to 5V DC. The TRIG pin is used to send out a signal. The ECHO pin is used to receive a signal. The GND pin is connected to ground.

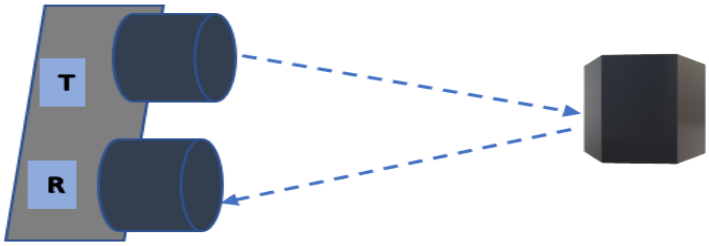

Fig -2: TRANSMITTER AND RECEIVER IN AN ULTRA SONIC DISTANCE SENSOR

The Ultrasonic distance sensor has a Transmitter that sends out an ultrasonic signal and receiver receives an ultrasonic signal. The Ultrasonic transmitter transmits an ultrasonic sound wave, this wave travels in air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module as shown in the picture. Ultrasonic sensors can measure distance and detect the presence of an object without making physical contact.

2.1 How to Calculate Distance?

The TRIG pin of the sensor has to be made high for 10uS and then turned off. This will generate an ultrasonic signal at frequency of 40Hz from the transmitter. Once the signal goes out of the transmitter, it propagates through air and hits the obstruction that is there in its path and bounces back. This bounced signal is then received by the Ultrasonic Receiver. Once the signal is returned after it getting reflected by any object the Echo pin goes high for a particular amount of time which will be equal to the time taken for the signal to return back to the sensor.

The amount of time during which the Echo pin stays high is measured. Using this information, the distance is measured as the speed of sound is already known.

To calculate the distance of an object using HC-SR04 Ultrasonic Sensor, if the transmitter sends out a signal at time **Time** $_{\textbf{start}}$ and the signal is received back at the receiver at time **Time** $_{\textbf{end}}$

Total Time taken for the signal to transmit and receive back (T)= Time $_{end}$ – Time $_{start}$

Time taken in one direction=T/2

Speed of ultrasonic sound waves in air as 34300cm/sec

Now we know time taken by the signal to go and strike the object and speed of sound, then we can calculate the distance.

Distance=T/2 X 34300

Distance=T x 17150

3. HARDWARE REQUIREMENT

We need to interface a microcontroller like raspberry pi with ultrasonic sensor in order to calculate the distance. To do this we need the following:

Table -1: Materials required

Components Name	Quantity	Description
Raspberry Pi 4 with 32GB micro-SD card	1	2GB RAM
Ultrasonic distance sensor	1	HC-SR04 is an ultrasonic sensor
5V out Power bank	1	Two USB Out: 5V, 2.1Amp 1Amp
Breadboard	1	Small size
Resistors	2	1k/2k
Jumper wires	4	Male to female jumper wires

3.1 Ultrasonic distance sensor circuit

In the Raspberry pi the GPIO pin corresponding to echo pin must be configured as Input pin and the GPIO pin corresponding to trig pin must be configured as output pin.[3]

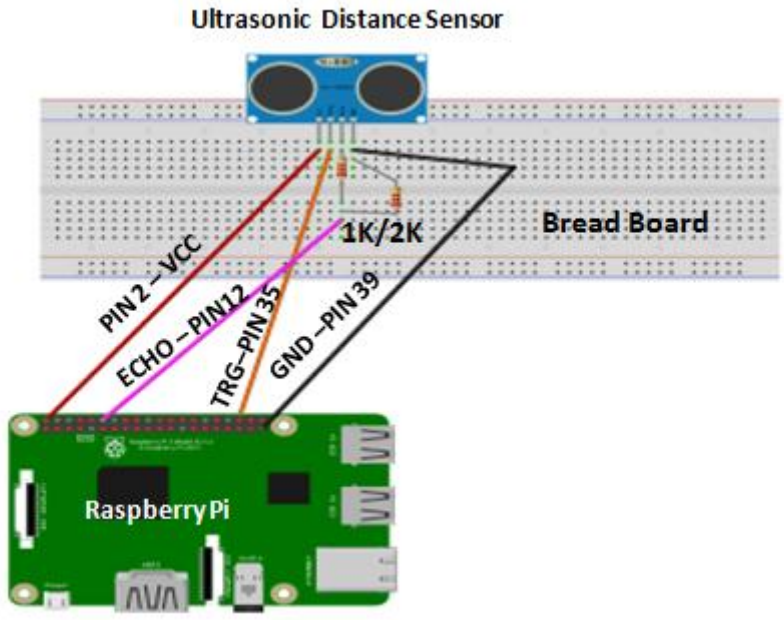

Fig -3: SENSOR CIRCUIT

- V_{cc} of the sensor will go into +5V of raspberry pi. Either to Pin # 2 or Pin # 4
- GND of the sensor will go into GND of raspberry pi
- Trig Pin of the sensor to Pin #35 of raspberry pi
- Echo Pin of the sensor into Pin # 12 of raspberry pi

3.2 Robot arm setup with Ultrasonic sensor

In this article we are using ready assembled robot arm for testing. If you need information on how to assemble robot arm please refer the assembly instruction given in this link.

Robot arm is interfaced with raspberry pi for control. Ultrasonic distance sensor is interfaced with raspberry pi as given in Fig 3. Sensor is attached to base of Robot arm facing towards the assembly line belt such a way that whenever any object move on the belt it will block ultrasonic signal from sensor.

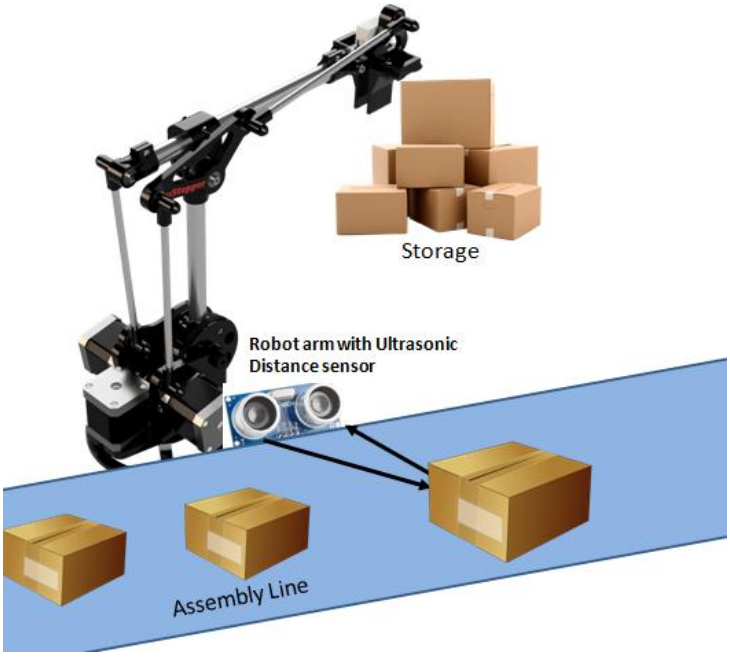

Fig -4: Robot arm and sensor setup to detect objects

4. SOFTWARE

In this project we have a two software module.

1. Ultrasonic distance calculation code
2. Robot arm movement code for pick and place

4.1 Ultrasonic distance calculation code

Section of code to calculate distance is given below.

Code is written in python and it follow equation explained in section 2.1

```
while True:
 time.sleep(2)
 GPIO.output(TRIG,1) #Send TRIG signal
 time.sleep(0.00001)
 GPIO.output(TRIG,0)
 while GPIO.input(ECHO) == 0: # Capture start time(Time start)
 pulse_start = time.time()
 while GPIO.input(ECHO) == 1:
 pulse_end = time.time() #Capture end time(Time end)
 pulse_duration = pulse_end - pulse_start # Time end- Time start gives total time of travel
 distance = pulse_duration * 17150
 distance = round(distance,2)
 print("distance: " + str(distance) + "cm") # Print distance
```

```
if distance <= 30 : # if distance is less than30cm, object is blocking

 Robotarmmove() # call robotarm movement module

GPIO.cleanup()
```

As given in last section of code, when object is in front of the sensor distance will be less than 30cm, this will trigger robot arm movement section of the code.

4.1 Robot arm movement for pick and place

Section of code is for predefined movement of the robot arm. This sample code provides flow of movement of one servo motor connected to robot arm. Same flow is used for all other servo motors on robot arm.[8][9]

```
if base<=60: #Set angle range to rotate

base =60

elif base>=240:

base=240

print "base rotate %s"%base #pre defined angle to rotate

cmd = "echo 3=%s > /dev/servoblaster" %base #create command to rotate servo

os.system(cmd)
```

5. WORKING

Once we have setup as given in Fig-4. Place a box or object in front of ultrasonic distance sensor. By default the distance calculated by sensor when there is no object in front will be greater than 200cm. When object is in front of the sensor distance will be less than 30cm, this will trigger robot arm movement section of the code.

Robot arm movement code will make predefined movement of making robot arm to pick object at specified location and place it in predefined place or box.

6. TESTING AND RESULT

When we run the ultrasonic distance sensor python code and robot arm code on raspberry pi, the sensor will display the distance to the target object kept in the front of robot arm. If object is present robot arm will pick object and place it in side. When we place next item in front of robot arm, it will pick and place.

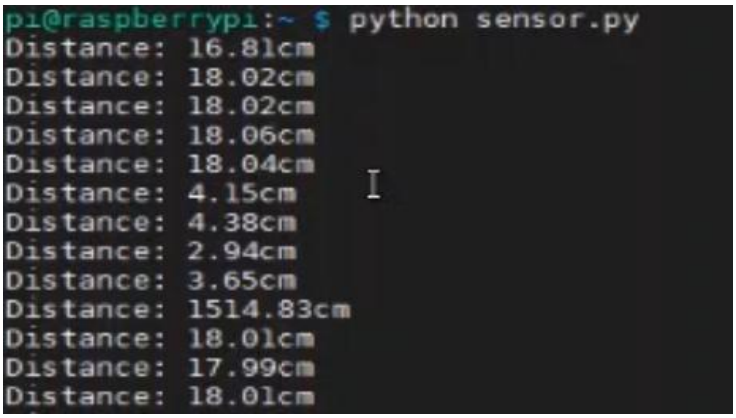

Fig -3: Distance to object result

7. CONCLUSION

In this paper, we are proposing a system that will detect object placed. The robot arm will pick and place the object with predefined movement once the object is placed. This is very useful in manufacturing and packaging industry to automate some of manual work at very low cost. This system will accurately detect object and this has proved to be working module. We believe that this system will be of great help to automate some of the manual process in manufacturing assembly line[4]

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